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# Kongeriget Danmark

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**Patent- og Varemærkestyrelsen**  
Økonomi- og Erhvervsministeriet

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Susanne Morsing

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Modtaget

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## Separation of crude oil at the well head

### Field of the invention

The present invention relates to separation of a  
5 mixture provided at the well head comprising crude  
oil, gas, water and solids into these constituents.

In particular the present invention relates to  
the use of a separator previous used as a combined  
degassing and flotation tank for the separation at  
10 the well head of an oil well for the initial  
separation into crude oil, gas, water and solids.

### Background for the invention

In the oil industry the production of crude oil  
15 involves pumping a mixture of oil, gas and water from  
subterranean reservoirs, also known as the bore  
fluid. At the well-head a initial separation usually  
takes place, and the crude oil still containing some  
gas and water is treated in one or more separators to  
20 remove more water and gas before the crude oil is  
ready for discharge from the platform.

After the initial separation the crude oil and  
the gas may be further purified prior to discharge  
for refining etc. The water and sand is usually  
25 optionally after further purification discharged into  
a suitable recipient such as the ocean or returned  
into the oil well.

With ageing of the oil fields one often finds  
that the volume of water accompanying the oil becomes  
30 much larger and consequently the larger volumes must  
be treated at the well head in order to maintain an  
acceptable production rate.

On oil production platforms intended for operation at sea very limited space is usually available. Therefore there are very strict constraints on the space available for installation of equipment. An even stricter constraint on space may be encountered if one considers the establishment of an oil production at the sea bed level.

In the prior art a number of oil-gas-water separators are known. In US 4,424,068 a separator and a method for separating a mixture of oil, gas and water, such as may be received from an oil-well is described. The separator is in the form of a vessel divided into separation chambers and provided with a number of baffles and a dynamic separator where the incoming mixture changes direction several times. Despite that the separator have been known for several years it seems not to have been widely used. Further as the separator comprises several chambers and many parts the maintenance will be time consuming which may lead to costly stop of oil production.

WO 99/20873 describes a sand trap that may be placed on an oil well in order to remove heavier particles such as sand before further processing of the crude oil. The device has a mouth towards a relatively narrow part of a tank with a spatial connection towards a relatively widened part of the tank where sand and heavy particles precipitate.

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Despite the number of known separation equipment for the initial separation at the well head there is

still a need for a new separation method providing a high separation efficiency, high capacity, low space requirement, with a low requirement for maintenance and which can be manufactured and operated at moderate price.

#### Brief description of the invention

These objects may be provided by using a separator as disclosed in WO 02/41965 A2 at the well head for performing the initial separation of the fluids coming from the oil well. WO 02/41965 A2 is incorporated in the present application by reference.

It has surprisingly been realized by the present inventors that the combined degassing and flotation tanks of WO 02/41965 A2 can be applied directly connected to the well head and perform the initial separation of the fluids from the oil into a oil fraction, a gas fraction, a water fraction and solids.

#### Brief description of the drawings

Fig 1. is a schematic section of one embodiment of the combined degassing and flotation tank according to WO 02/41965. In the figure (1) is the tank, (2) tangential inlet, (3) outlet for oil and gas, (4) outlet for water, (5) first inner concentric cylindrical wall extending from the top of the tank and (6) the second inner concentric wall (6) extending from the bottom of the tank and having a smaller diameter than the first inner concentric cylindrical wall.

Fig 2. is a schematic section of another embodiment of the combined degassing and flotation tank according to WO 02/41965. In the figure (1) is the tank, (2) the tangential inlet, (3) outlet for oil and gas, (4) outlet for water, (8) outlet for solids, (10) inner cylinder and (12) inlet guide vane.

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#### Detailed description of the invention

In one preferred embodiment of the present invention the separator used for the separation comprises an essentially cylindrical vertical tank (1), a tangentially arranged inlet (2), at least one outlet (3) for gas and oil in the upper part of the tank, an outlet (4) for water placed in the lower part of the tank, an outlet (8) for solids in the lower part of the tank and a first inner concentric cylindrical wall (5) extending from the top of the tank forming a flotation and degassing zone between said inner concentric wall and the wall of the tank in the upper part of the tank and optionally a second inner concentric wall (6) extending from the bottom of the tank and having a smaller diameter than the first inner concentric cylindrical wall (5) (fig 1).

In another preferred embodiment of the present invention the separator used for the separation comprises an essentially cylindrical vertical tank (1), a tangentially arranged inlet (2), at least one outlet (3) for oil and gas in the upper part of the

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tank, an outlet (4) for water placed in the lower part of the tank, an inner concentric wall (10) formed as a cylinder placed in the upper part of the tank leaving an open space between said cylinder and the top of the space, and further leaving a space between said cylinder and the bottom of the tank, an outlet (8) for solids placed in the lower part of the tank, and optionally provided with an inlet guide vane (11) placed between the tank (1) and the inner cylinder (10) leaving an open space between the inner cylinder and the inlet guide vane (11), and further optionally provided with a concentrically arranged horizontal circular plate (12) having a smaller diameter than the tank placed in the lower part of the tank above the outlet for water (4) and solids (8).

If the separator to be used according to the invention contains only one outlet for oil and gas the oil and gas will be provided from the separator as one oil/gas fraction which subsequently may be separated to oil and gas fractions depending on the actual composition of the hydrocarbon of the particular well and the intended use of the hydrocarbon.

It is preferred that the separator contains separate outlets for oil and gas. The skilled person will appreciate how to arrange the apertures of the outlets for oil and gas in order to obtain separate fractions.

Further details of the separators to be used according to the invention can be found in WO 02/41965.

After the initial separation of the bore fluid the water and oil fractions will still contains some dissolved gas that may subsequently be removed using  
5 known procedures. It will be appreciated that the amount of gas contained in the gas and oil fractions will depend on the actual conditions in the separator such as temperature, pressure and residence time.

10 Fluids to be separated according to the present invention are bore fluids coming directly from the well. Usually the fluid is composed of more that 10% hydrocarbons, preferably is the content of hydrocarbons in the range of 30-99% more preferred in  
15 the range of 50-99%, where the remainder is water, non hydrocarbonaceous gases and solids, such as sand and other minerals present in the subsurface. The fluid may also contain chemicals added to the subsurface in order to improve the amount of oil that  
20 can be recovered, as it will be known the skilled person.

The separator will usually be operated at a pressure determined mainly of the pressure with which  
25 the fluid leaves the well head, however the pressure may also be increased or reduced before entering the separator using known procedures. The separator may be operated at a pressure between atmospheric pressure and approximately 100 bars. Preferably the  
30 pressure is in the range of 10-50 bars.

The dimensions of the separator may be selected depending on the amounts of fluid intended to be



treated. In operation it has been found that the residence time in the tank for a fluid to be treated may be selected between 5 and 300 seconds, preferably 5 - 150 seconds, more preferred 10 - 60 seconds, even more preferred 10-40 seconds. A particular preferred residence time is about 20 seconds.

For the combined degassing and flotation tank according to the invention, an efficient flotation volume may be calculated as the volume of the space bounded by the tank (1) and the height of the liquid in the tank. Based on the residence time the capacity of the tank may be calculated e.g. a tank with a efficient flotation volume of 1 m<sup>3</sup> and a residence time for the liquid of 20 seconds has a capacity of 180 m<sup>3</sup> per hour.

The ratio of height to diameter of the tank can be selected within wide limits preferably in the range of 1:1 to 4:1 more preferred from 1:1 to 2:1.

It is within the skills of the person skilled in the art to select materials used for the construction of the tank based on the actual conditions for the intended use, such as the amounts of liquid to be treated, the composition of said liquid, the selected pressure, the temperature of the liquid and the presence of possible corrosive chemicals in any of the phases of the mixture.

During operation the rate with which the separated phases are withdrawn via the respective outlets determines where the interphases between gas and oil, oil and water and water and solids are located in the tank. The skilled person will

appreciate how to adjust the rate of withdrawal via the respective outlets so that the optimal separation will be achieved.

5        Because of the way the separators according to WO 02/41965 are formed all surfaces are vertical or at least having a steep inclination or subjected to a rapid flow, which prevents deposit of solids, with the exceptions of the surfaces in the sectors  
10 intended for collection of particulate material and sludge, which sectors also preferably have outlets for removal of these materials. Further no narrow passages are present in the tank. Consequently there is no place in the separator, which is susceptible to  
15 clogging or deposition of solid materials. Therefore the initial separation of the bore fluid at the well head may be performed essentially continuously without or only with a minimal need for maintenance.

Further maintenance, when it is necessary even  
20 though it is infrequent, can easily be performed from the top of the separator, which preferably is constructed to be removable.

Thus the separation of the bore fluid at the  
25 well head according to the invention has a remarkable robustness i.e. it can be run for long periods without interruptions, and the few stops that may be required for maintenance can be made short.

30        The high capacity combined with the small occupied space and the robustness of the separation according to the invention makes it particular suited

for use at off-shore oil plants such as oil production platforms. Further it is also well suited for use in oil production in plants located on the sea bed, because at such a location the constraints  
5 on space may be even stricter than on traditional oil production platforms and the capacity for maintenance may be lower.

10        Now the invention is described by examples, which should not be regarded as limiting for the invention.

#### EXAMPLES

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## C L A I M S

1. Use of a separator comprising an essentially  
5 cylindrical vertical tank (1), a tangentially  
arranged inlet (2), at least one outlet (3) for gas  
and oil in the upper part of the tank, an outlet (4)  
for water placed in the lower part of the tank, an  
outlet (8) for solids in the lower part of the tank  
10 and a first inner concentric cylindrical wall (5)  
extending from the top of the tank forming a  
flotation and degassing zone between said inner  
concentric wall and the wall of the tank in the upper  
part of the tank and optionally a second inner  
15 concentric wall (7) extending from the bottom of the  
tank and having a smaller diameter than the first  
inner concentric cylindrical wall (5), for the  
initial separation of the fluid from an oil well.

2. Use of a separator comprising an essentially  
20 cylindrical vertical tank (1), a tangentially  
arranged inlet (2), at least one outlet (3) for oil  
and gas in the upper part of the tank, an outlet (4)  
for water placed in the lower part of the tank, an  
inner concentric wall (10) formed as a cylinder  
25 placed in the upper part of the tank leaving an open  
space between said cylinder and the top of the space,  
and further leaving a space between said cylinder and  
the bottom of the tank, an outlet (8) for solids  
placed in the lower part of the tank, and optionally  
30 provided with an inlet guide vane (11) placed between  
the tank (1) and the inner cylinder (10) leaving an  
open space between the inner cylinder and the inlet

guide vane (11), and further optionally provided with a concentrically arranged horizontal circular plate (12) having a smaller diameter than the tank placed in the lower part of the tank above the outlet for 5 water (4) and solids (8), for the initial separation of the fluid from an oil well.

3. Use according to claim 1 or 2, wherein the fluid from the oil well comprises 30-99 % hydrocarbon.

10 4. Use according to claim 1 or 2, wherein the pressure in the tank is from atmospheric pressure up to 100 bars.

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19/7/02

Separation of crude oil at the well head

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# A B S T R A C T

The initial separation of the fluid provided  
10 from an oil well using a separator previously known  
only from the area of degassing and flotation of  
process water from oil recovery.



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Varemærkestyrelsen

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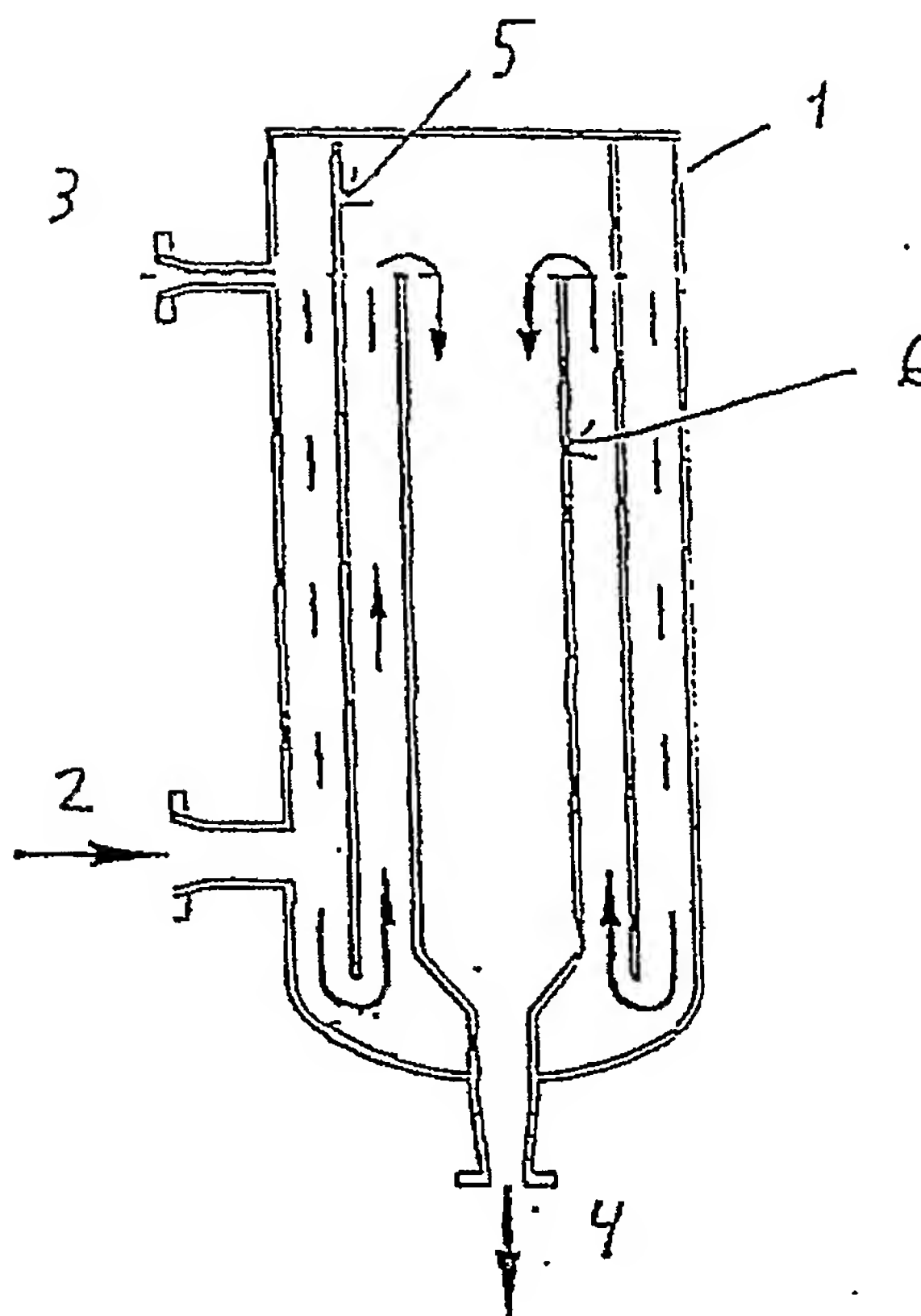


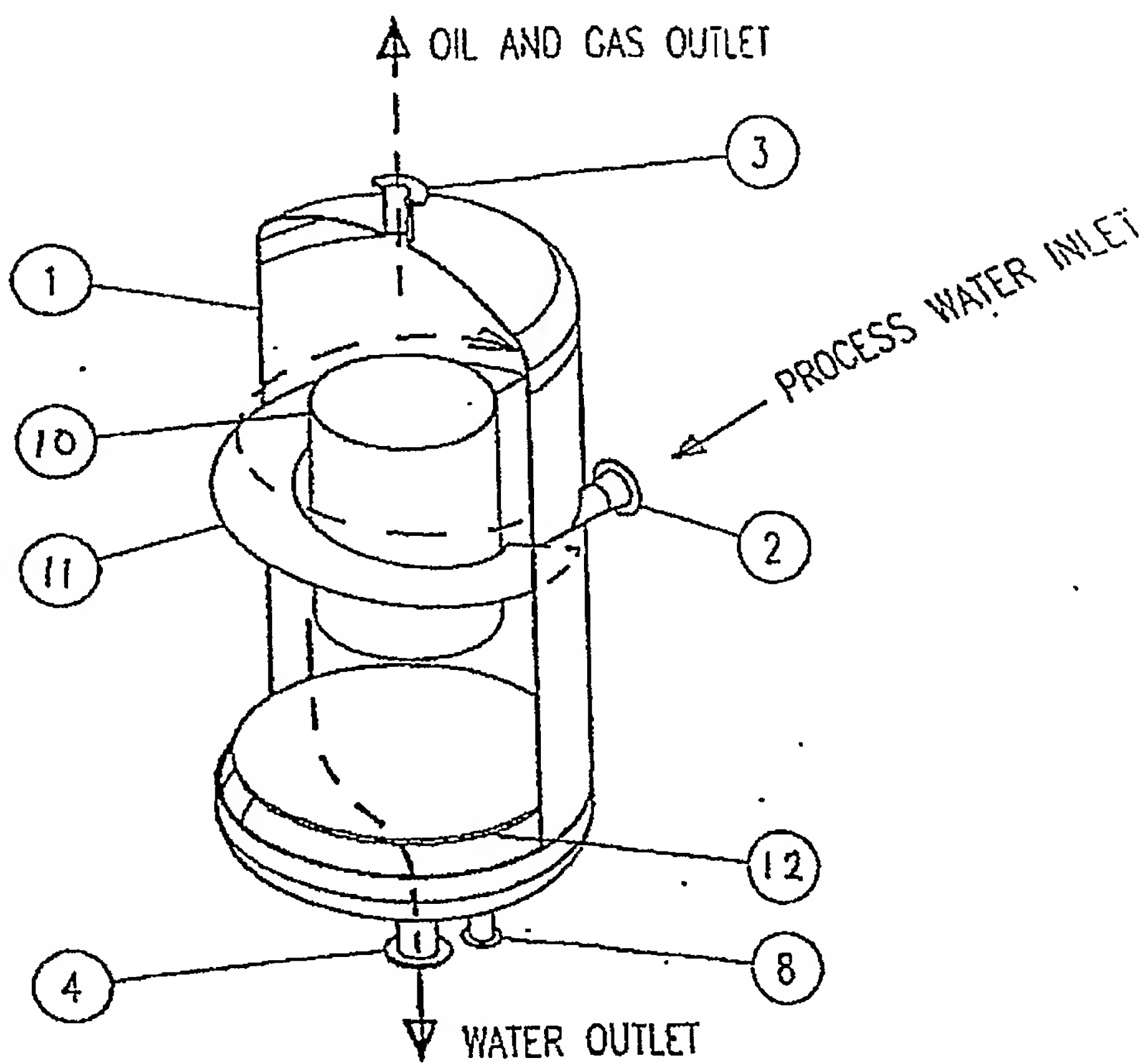
Figure 1.

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## DEGASSING AND FLOTATION TANK

- 1. TANK
- 2. INLET
- 3. OIL AND GAS OUTLET
- 4. WATER OUTLET
- 12. HORIZONTAL PLATE
- 10. INNER CYLINDER
- 11. INLET GUIDE VANE
- 8. SLUDGE OUTLET



Figure